WORK SHARE AGREEMENT

BETWEEN

RUTHERFORD APPLETON LABORATORY

AND

THE EARTH OBSERVING SYSTEM PROJECT OFFICE

AT

THE GODDARD SPACE FLIGHT CENTER

FOR

THE PHASE C/D/E WORK TO BE PERFORMED ON THE EARTH OBSERVING SYSTEM

HIGH RESOLUTION DYNAMICS LIMB SOUNDER (HIRDLS)

JANUARY 6, 1997

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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JANUARY 6, 1997

Approved by:

Signature of _____ 10/1/97
Richard Holdaway Date
UK EOS Program Director

Signature of _____ 3/11/97
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NASA Goddard Space Flight Center
Greenbelt, Maryland

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LIST OF AFFECTED PAGES

Page No.	Revision	Page No.	Revision	Page No.	Revision
Cover Page	Original				
Signatures	Original				
ii	Original				
iii	Original				
iv	Original				
v	Original				
1	Original				
2	Original				
3	Original				
4	Original				
5	Original				
6	Original				
7	Original				
8	Original				
9	Original				
10	Original				
11	Original				
12	Original				
13	Original				
14	Original				
15	Original				
16	Original				
17	Original				
18	Original				
19	Original				
20	Original				
21	Original				
22	Original				

EOS 420-CM-04 (4/92)

Table of Contents

Table of Contents

SECTION **PAGE**

1.0 BACKGROUND

The High Resolution Dynamics Limb Sounder (HIRDLS) is an atmospheric measurement instrument selected for the National Aeronautics and Space Administration's (NASA's) Earth Observing System (EOS) Chemistry Spacecraft. The instrument will be built and used jointly by an international team from the United States of America (USA) and the United Kingdom (UK). The US team consists of the University of Colorado at Boulder (CU) and its subcontractors. The CU office responsible for this team is referred to as the HIRDLS Project . In addition, CU is responsible for the overall technical coordination of both the US and UK HIRDLS instrument teams. This office is referred to as the HIRDLS Program. The UK team consist of Oxford University, Reading University, Rutherford Appleton Laboratory (RAL) and their subcontractors. This team will use the data generated by the instrument to investigate mass flow and constituents, and inter-annual variability and trends of the middle atmosphere. HIRDLS is a multi-channel limb-viewing IR radiometer for high resolution monitoring of upper tropospheric, stratospheric, and mesospheric temperature, trace chemicals, and geopotential height gradients. HIRDLS will improve on present and previous middle atmospheric measuring instruments by providing high spatial resolution on scales that are dynamically consistent horizontally and vertically. HIRDLS will have an in-orbit lifetime requirement of 5 years with a goal of 6 years without in-orbit manned servicing.

2.0 SCOPE

A Letter of Agreement (LoA) prepared between the UK Natural Environment Research Council (NERC) and the USA NASA defines the overall obligations of both nations and the general framework for the development of the HIRDLS instrument. This document, hereafter called the Work Share Agreement (WSA), details those obligations contained in the LoA, between RAL (representing NERC) as one party and the EOS Chemistry and Special Flights Project (CSFP) Office at the Goddard Space Flight Center (GSFC) of the NASA as the other party.

The Work Share Agreement also identifies deliverable items for the EOS hardware, ground support, science hardware/software, and post-launch programs for the USA and the UK portions of the HIRDLS instrument. The specific implementation of these obligations is described in the HIRDLS Management Plan and the Work Packages (WPs). If any differences exist between these various documents the order of precedence, in order of priority, is the LoA, Work Share Agreement, Management Plan, and Work Packages.

The Program has been divided into three phases, namely a systems requirement and design concept phase (also called phase I or phase B); an instrument development, integration, test, calibration, development of post launch software and launch phase (also called phase II or phase C/D); and a post-launch support and data processing phase (also called phase III or phase E). Phases C/D/E, contained in this Work Share Agreement, shall include the period from Systems Concept Review (SCR) till 90 days following the launch of the Chemistry Spacecraft for Phases C/D and till the end of the mission for Phase E.

3.0 PROGRAM DESCRIPTION

The objective of the HIRDLS Phase B effort was to understand the implications of the science and engineering requirements as they apply to the HIRDLS instrument in sufficient detail to develop a mature conceptual design of the instrument and enable an accurate assessment of cost and schedule. The scope of this agreement is based on those accomplishments of the Phase B system requirement and design concept efforts.

The objective of the HIRDLS Phase C/D will be the final design/development of the instrument. This includes the resources necessary for the instrument design, analysis, development, fabrication, integration, test, calibration, acceptance, storage, storage testing, and support for spacecraft integration, test and launch of the HIRDLS instrument. Instrument support at the spacecraft facilities include post-delivery spacecraft bench testing, spacecraft integration and environmental testing, and pre and post launch operations. Also included is the Mission Operations & Data Analysis (MO&DA), including instrument operations, Science Computing Facility (SCF) operations for the data processing, algorithm software development and maintenance, dissemination and scientific application of the data, and the planning for the instrument's maintenance operations. The effort will include an Engineering Model, a ProtoFlight Model (PFM), Ground Support Equipment (GSE), test and calibration equipment.

The objective of the HIRDLS Phase E will be to support the Mission Operations and Data Analyses (MO&DA) for the operations/data analysis phase after launch which includes post-launch support of the instrument, establishing SCFs for the data processing, dissemination and scientific application of the data, and the instrument's maintenance operations.

In order to perform the above efforts, a HIRDLS instrument team has been assembled consisting of management and system engineering personnel from both the USA and the UK. The organization of the program is summarized in Section 4.0 in this document and detailed in the HIRDLS Management Plan. The assignment of specific responsibilities is summarized in Section 5.0 of this document and detailed in the HIRDLS WPs.

4.0 PROGRAM ORGANIZATION

The HIRDLS Program is organized to accommodate the division of the management of resources between the USA and the UK. The HIRDLS Program Office maintains the HIRDLS Program Management Plan which provides details on the organizational structure, functional responsibilities, and operating procedures for the program. Even though the management of resources has been divided, it is advantageous to both parties that certain central functions be led by one or the other party. These include program management and administration, system engineering, and coordination of other management functions such as configuration management and quality assurance.

The CSFP is the single point of responsibility for monitoring the development of the HIRDLS instrument for flight on the EOS Chemistry Mission. The USA HIRDLS Project, under the authority of NASA/GSFC, has been contracted to CU. All resources, such as funding, for the USA HIRDLS Project, including the USA functional responsibilities and hardware deliverables as specified in this document, will be supplied by the USA.

The primary UK funding for HIRDLS is provided by the NERC. NERC has designated RAL as the establishment responsible for administering and monitoring the overall development of the HIRDLS Project in the UK. All resources, such as funding, for the UK component of the HIRDLS Project, including the UK functional responsibilities and hardware deliverables listed in this document, will be supplied by the UK.

As defined in the HIRDLS Management Plan, the HIRDLS Program Team will meet regularly to coordinate, provide direction, and resolve all policy issues. This Program Team consist of the USA and UK Co-Principal Investigators, the UK EOS Program Director, and the USA CSFP representative.

The HIRDLS Science Team is under the direction of Co-Principal Investigators Dr. John Gille at CU and Dr. John Barnett at Oxford University.

5.0 DIVISION OF RESPONSIBILITIES

The HIRDLS program has an international division of subsystems and functions that requires an organizational structure capable of centrally coordinating the functions of technical direction, resource allocation, and administration. Also, effective management control systems must be implemented for authorizing, scheduling, and tracking the work performed during the course of the Instrument program. The organization of the program, the detailed assignment of functional responsibilities, and the management operating procedures are provided in the HIRDLS Management Plan and the HIRDLS Work Packages (WPs).

The HIRDLS Program shall meet the instrument interface and performance assurance requirements as specified in the Common Spacecraft General Instrument Requirements Document (GIRD) and the Mission Assurance Requirements (MAR) for the High Resolution Dynamic Limb Sounder (HIRDLS) Instrument. The flight resident and operations software shall be developed in accordance with the requirements specified in the GIRD, the Instrument Technical Specification (ITS), and the CSFP Software Management Plan (SMP). Delivered software will be according to theEOS C&SF Instrument Software Management Requirements Document.

The details of those obligations for each of the prime organizations are defined below. Through a coordinated effort these responsibilities may be modified by consent of RAL & CSFP.

5.1 USA Obligations

The following sections detail those USA obligations contained in the LoA. The specific implementation of these obligations are described in the HIRDLS Management Plan and the HIRDLS WPs.

5.1.1 Program Management

The Program Office at CU will be responsible for the overall program management of the HIRDLS instrument. The program management function shall include program management, technical management, configuration management, performance assurance, and administration of the overall HIRDLS Program.

5.1.2 System Engineering

The USA is responsible to support the UK, as necessary, to allow them to complete their obligations as defined in section 5.2.2. This may include, but is not limited, to the following:

1. Perform the system trade studies, requirement analyses, and flow down of science requirements to instrument requirements along with instrument compliance;

2. Development, integration and finalization of all overall models;

3. Review and approval of both US and UK subsystem specifications; and

4. Identification of resources for performing engineering activities associated with US subsystems and the integration, testing and verification of the instrument which shall include instrument level reliability and contamination analyses, subsystem specifications and interface requirements.

5.1.3 Instrument Integration

The USA will be responsible for instrument integration including the following:

1) Overall instrument layout and coordination of instrument interfaces and documentation;

2) Coordination of instrument subsystem specifications and designs;

3) Overall instrument thermal design, integration and verification of the final instrument level structural and thermal mathematical models; and

4) Definition and validation of the instrument interface with the spacecraft.

5.1.4 Configuration Management

The USA will be responsible for configuration management of the overall HIRDLS instrument. This function shall establish the organizational responsibilities for implementing the HIRDLS configuration management system, top-level policies for configuration identification, configuration change control, configuration status accounting and configuration verification. The configuration management of the overall HIRDLS instrument shall cover all of the documentation, hardware and software. The configuration management system implemented shall be in accordance with NASA standards. The USA shall implement a configuration management system as defined in the HIRDLS Configuration Management Plan.

5.1.5 Performance Assurance

Implement and maintain a Performance Assurance (PA) program to ensure that the HIRDLS instrument meets all functional requirements, has been manufactured and tested properly, and will operate as specified. This program shall be implemented by conducting analyses, reviews, tests, and inspections, and by appropriate management of the associated records, reports, and other PA-related documentation.

The PA program shall encompass all flight hardware and software including flight spares and associated customer and government-furnished flight equipment. It shall also apply to GSE that interfaces directly with flight hardware. Non-flight equipment is not required to meet the exacting standards required for flight hardware, but shall be built per good manufacturing practices.

5.1.6 Hardware Development

The USA will provide the resources necessary to specify, design, build, test and deliver the following subsystems, as defined in the HIRDLS Work Breakdown Structure:

1. Detector Subsystem(DSS): this includes the efforts to specify, design, build, test, verify and integrate a DSS EM, PFM, and all associated GSE. The USA will coordinate the design of the UK focal plane optical filter elements with the DSS and mount them into the DSS;

2. Telescope Subsystem (TSS): this includes the efforts to specify, design, build, test, verify and integrate a TSS EM, PFM, and all associated GSE. The USA will

coordinate the design of the UK warm bandpass defining optical filter elements with the TSS and mount them into the TSS;

3. Instrument Processor Subsystem (IPS): this includes the effort to specify, design, build, test, verify and integrate the IPS EM, PFM, including all instrument harnesses, and all associated GSE. The IPS must interface with the Sunshield Subsystem (SSH), Gyro Subsystem (GSS), and In-Flight Calibrator Subsystem (IFC), which shall be provided by the UK, and the Cooler Subsystem (CSS). Any embedded firmware or software shall be fully developed and tested at delivery. The USA shall be responsible for the design, test, verification and integration of the IPS Flight Software. An IPS simulator to functionally test the IPS flight software will be developed;

4. Cooler Subsystem (CSS): this includes the efforts required to design, fabricate, test and verify the CSS EM, PFM, and associated GSE.

5. Instrument Integration, long term storage, and storage testing;

6 The Acceptance Test Station (ATS) that is used to perform the radiometric/optical and line of sight calibration tests at the Instrument Integrator facility.

7. Internal instrument purging that includes, but is not limited to ,purge tubing connectors and associated hardware, and purge gas when in the hardware is in the USA;

5.1.7 Instrument Software Development

The USA will be responsible for the specification, design, development, test, verification, and on-orbit maintenance of the flight software. Instrument flight software is the instrument resident software that controls the on-board operational activities of the instrument. These activities include internal monitoring and status reporting; command and data macro interpretation; on-board science data processing; data packetization for delivery to the Command and Data Handling (CD&H) subsystem; tests to monitor performance; internal calibration functions; and detection and identification of faults and malfunctions.

5.1.8 Instrument Flight Operations Software

The USA is responsible to support the UK, as necessary, to allow them to complete their obligations as defined in section 5.2.8.

5.1.9 Instrument Ground Support Equipment

The Instrument Ground Support Equipment (IGSE) is comprised of the Mechanical Ground Support Equipment (MGSE), the Electrical Ground Support Equipment (EGSE), the Thermal Ground Support Equipment (TGSE), Radiometric Ground Support Equipment (RGSE) and associated software that will be provided to the spacecraft contract with the instrument. The MGSE, EGSE, TGSE, and RGSE is defined as what is necessary to integrate and test the instrument at the subsystem to system level. The MGSE, EGSE, and TGSE includes but is not limited to specialized software and cabling necessary to allow the subsystems to be integrated and tested at the instrument optical, electrical and thermal interfaces. Also, mechanical interface templates, alignment fixtures, contamination plugs, internal purge fixtures, caps and covers and handling and locking fixtures required for safe handling shall be provided. Software includes the software needed to test the instrument and integrate it with the spacecraft. This software may also be used during the operations phase for flight performance analysis. It includes instrument interface and test software needed by the spacecraft to test the spacecraft-to-instrument interfaces. The USA responsibilities for IGSE are:

5.1.9.1 MGSE

The USA shall support the UK in delivery of the Instrument System drill templates and alignment fixtures to the spacecraft contractor.

5.1.9.2 EGSE

The USA is responsible to support the UK, as necessary, to allow them to complete their obligations as defined in Section 5.2.9.2.

5.1.9.3 TGSE

The USA is responsible to support the UK, as necessary, to allow them to complete their obligations as defined in section 5.2.9.3.

5.1.10 Ground Data Systems Software and Operations

The USA will have primary responsibility for delivery, integration, and test of standard data product generation software for HIRDLS and will provide the principal point-of-contact for liaison between the HIRDLS instrument team and the EOS Data and Information System (EOSDIS) regarding mission data processing operations. All standard data product software delivered will conform to ESDIS requirements. The following sections specify required software and operations support.

5.1.10.1 Software

5.1.10.1.1 DAAC Standard Data Product Software

The USA shall supply the resources necessary for the design, development, installation and maintenance of Level-2 and Level-3 standard data product generation software. This will include in-line data product quality assurance software that will run at the EOSDIS Distributed Active Archive Center (DAAC). In addition, the USA will support the UK in the development of the Level-1 standard data product generation software and receive the various modules developed by the UK for integration into a comprehensive HIRDLS product software suite prior to delivery to the DAAC. The USA will support ESDIS in the test and maintenance of the complete suite of data product generation software.

5.1.10.1.2 Data Archive Support Software

The USA shall be provide the resources required to develop software in support of the archiving of HIRDLS standard data products. This includes software for formatting, packaging, metadata generation, status reporting, data user browse products, data user access software and user data product documentation.

5.1.10.1.3 Mission Data Processing Operations Support Software

The USA shall supply the resources necessary to design, develop and maintain SCF based software necessary to monitor on-going data processing operations, including data product quality assurance at the DAAC.

5.1.10.1.4 Instrument Flight Operations Support Software

The USA is responsible to support the UK in the specification of instrument flight operations support software requirements and the review of the software to support mission planning and flight operations of the HIRDLS instrument.

5.1.10.2 Mission Operations

5.1.10.2.1 Mission Data Processing Operations

The USA will provide the principal point-of-contact for liaison between the HIRDLS Instrument Team and the EOSDIS regarding mission data processing operations. In addition, the USA will provide data product quality assurance and long-term instrument performance monitoring.

5.1.10.2.2 Instrument Flight Operations

The USA is responsible to support the UK in the areas of mission planning and instrument flight operations and on an alternating basis assume responsibility for operation of the commanding IST (i.e. the IST from which NASA accept input to their commanding operations). Along with the UK the USA will monitor the instrument at all times using their IST.

5.1.11 Deliverables

The USA is required to deliver the following to the UK:

1. Internal Interface Control Document, containing agreed parameters which define the interfaces between all subsystems;

2. External Interface Definition Document, containing agreed parameters which define the interfaces between the spacecraft and the HIRDLS instrument;

3. Subsystem Specifications (MIL-STD-490A format or equivalent) for the USA subsystems;

4. Schedule estimates for the detailed design, fabrication and test of an EM and one PFM with spares as required for each of the subsystems defined in paragraph 5.2;

5. Instrument integration plan with schedule estimates for integrating the instrument EM and PFM;

6. Acceptance test plan with schedule estimates for performing instrument acceptance testing;

7. The USA SCF Plan (for informational purposes);

8. Integrated Engineering Model with support documentation for initial calibration testing; and

9. Fully integrated PFM with support documentation for instrument calibration.

The USA is required to deliver the following to GSFC:

1. Instrument Structural and Thermal Math Models;

2. Fully integrated, tested, and calibrated PFM to the spacecraft contractor to meet a launch date no later than December 2002;

3. Engineering Version (V1) of the standard data product generation software including associated test data. This version will demonstrate all the major functional capabilities and a complete operator interface including the generation of all needed messages using standard error and message services. This version will require realistic computational resources, near those of version V2;

4. Launch Version (V2) of the standard data product generation software including associated test data. This version will be a launch ready, complete, verified, and operational software system. Configuration management will be implemented with this version; and

5. Updated versions of the standard data products including associated test data. To be provided as appropriate after the delivery of V2.

GSFC is required to deliver the following to the HIRDLS Program:

1. Spacecraft documentation, specifications and program schedules that may be required;

2. Spacecraft interface mounting hardware (including Kinematic mounts if specified);

3. Copies of EOS/DIS tool kits software that is required in order to develop HIRDLS integration and test and data processing software for operations;

4. Mission planning information (e.g., orbital predictions) that may be required to plan HIRDLS observing sequences;

5. Access to the EOS POC and EOS/DIS systems; and

6. HIRDLS science/engineering data down linked from the spacecraft and required spacecraft data for HIRDLS operation and data processing.

5.2 UK Obligations

The following sections detail those UK obligations contained in the LoA. The specific implementation of these obligations are described in the HIRDLS Management Plan and the HIRDLS WPs.

5.2.1 Instrument Program Management

The UK is responsible to support the USA, as necessary, to allow them to complete their obligations as defined in Section 5.1.1

5.2.2 System Engineering

The UK will be responsible for the program level system engineering. This function shall include:

1) Flow-down of the Science and Instrument Requirements to instrument sub-systems;

2) Establishment of system level budgets for the instrument, calibration facility and GSE;

3) Performance of program level analyses and trades, including analysis of the optical design;

4) Responsibility for ensuring the instrument performance meets the science requirements; and

5) Coordination of instrument verification and validation requirements.

5.2.3 Instrument Integration

The UK is responsible to support the USA, as necessary, to allow them to complete their obligations as defined in Section 5.1.3.

5.2.4 Configuration Management

The UK is responsible to support the USA, as necessary, to allow them to complete their obligations as defined in Section 5.1.4. The UK shall implement a UK project configuration management system as defined in the HIRDLS Configuration Management

Plan to cover all of the flight hardware flight software, science computing facility and science software that is their responsibility to provide.

5.2.5 Performance Assurance

The UK is responsible to support the USA, as necessary, to allow them to complete their obligations as defined in Section 5.1.5. The UK shall implement a quality assurance program covering all of the hardware and software that is their responsibility to provide.

5.2.6 Hardware Development

The UK will provide the resources necessary to specify, design, build, test, calibrate and deliver the following subsystems and services, defined in the HIRDLS Work Breakdown Structure:

1. Uncut warm and cold optical filter for each HIRDLS channnel of the TSS and DSS respectively, Warm and cold filter elements, cut to size for HIRDLS EM and PFM models. Quantities and bandpass to be agreed and specified in a controlled project document;

2. In Flight Calibration (IFC) Subsystem: this includes the efforts required to specify, design, build, test, verify and integrate a EM, PFM, and all associated test and flight hardware and GSE, with the exception that the USA will manufacture the parabolic mirror to UK specifications.

3. Structure and Thermal Subsystem (STH): this includes the effort required to design, fabricate, test and verify the STH EM and PFM. Mathematical thermal and structural models for the UK provided subsystems are to be supplied for incorporation into the overall instrument model.;

4. Sunshield Subsystem (SSH): this includes the efforts required to design, fabricate, test and verify the SSH EM, PFM, and associated GSE.

5. Gyroscope Subsystem (GSS): this includes the efforts required to design, fabricate, test and verify the GSS functional EM, PFM, and associated GSE.;

6. The instrument MGSE, EGSE, and TGSE;

7. The calibration facility necessary to perform the radiometric spectral and Field-of-View (FOV) calibration of the EM and PFM. Included are the calibration requirements and plans, and facility planning, design, fabrication, verification and contamination control;

8. Power Subsystem (PSS): this includes the effort to design, build, test, verify and integrate the PSS EM, PFM and all associated GSE.

5.2.7 Instrument Software Development

The UK is responsible to support the USA, as necessary, to allow them to complete their obligations as defined in Section 5.1.7.

5.2.8 Instrument On-Board Control Sequences

The UK is responsible for the development, test, verification, and maintenance of the instrument on-board control sequences. The instrument flight operations on-board control sequences includes the instrument command software which contains the commands and functions required to command and control the instrument.

5.2.9 Instrument Ground Support Equipment

The instrument ground support equipment includes the MGSE, EGSE, TGSE, and any associated software. The MGSE, EGSE, and TGSE is defined as what is necessary to integrate and test the instrument at the subsystem to system level. The MGSE, EGSE, and TGSE includes but is not limited to specialized software and cabling necessary to allow the subsystems to be integrated and tested at the instrument optical, electrical and thermal interfaces. Also, mechanical interface templates, alignment fixtures, contamination plugs, caps and covers and handling and locking fixtures required for safe handling shall be provided. Software includes the software needed to test the instrument and integrate it with the spacecraft. This software may also be used during the operations phase for flight performance analysis. It includes instrument interface and test software needed by the spacecraft to test the spacecraft-to-instrument interfaces. The UK responsibilities for GSE are:

5.2.9.1 MGSE

The UK shall provide the Subsystem MGSE for the STH, SSH, GSS, and the IFC. Also provided is the HIRDLS instrument system MGSE including the shipping container, handling fixtures, purge equipment, lifting equipment and spacecraft drill template.

5.2.9.2 EGSE

The UK shall provide the instrument system EGSE hardware, emulator, I/F units, processor peripherals, and ground test software including the instrument simulator software, system software, application software, and an OASIS compatible data base.

5.2.9.3 TGSE

The UK shall provide an instrument cooling plate.

5.2.10 Ground Data Systems Software and Operations

All standard data product software delivered will conform to ESDIS requirements. The following sections specify required software and operations support.

5.2.10.1 Software

5.2.10.1.1 DAAC Standard Data Product Software

The UK shall develop, deliver to the USA and support installation and maintenance of the Level-1 standard data product generation software. The UK will support the USA in the development of the Level-2 and Level-3 standard data product generation software and their integration into a comprehensive HIRDLS product software suite prior to delivery to the DAAC.

5.2.10.1.2 Data Archive Support Software

The UK is responsible to support the USA, as necessary, in support of the software development activities described in Section 5.1.10.1.2

5.2.10.1.3 Mission Data Processing Operations Support Software

The UK is responsible to support the USA, as necessary, in support of the software development activities described in Section 5.1.10.1.3

5.2.10.1.4 Instrument Flight Operations Support Software

The UK shall provide the mission planning and instrument flight operations support software. This includes software which monitors and reports housekeeping,

instrument operation and performs malfunction detection, and isolation and will operate within the HIRDLS IST. In addition, this software shall provide means to translate high level definitions of observing scenarios into a form compatible for use by the on-board instrument processor.

5.2.10.2 Mission Operations

5.2.10.2.1 Mission Data Processing Operations

The UK is responsible to support the USA in mission data processing operations as described in section 5.1.10.2.1.

5.2.10.2.2 Instrument Flight Operations

The UK is responsible for mission planning and instrument flight operations during pre-launch tests and in the initial post-launch period. The UK will have responsibility for operation of the commanding IST on an alternating basis with the USA. Along with the USA, the UK will monitor the instrument at all times using their IST.

5.2.10.2.3 Flight Operations Procedures, Loads and Sequences

The UK is responsible for developing mission operation procedures, in conjunction with the USA and NASA, which after the initial post-launch period will form the basis for subsequent instrument operations. The UK is also responsible for generating instrument microloads, STOL/activation sequences, command loads, activity plans, etc. and for coordinating the development and testing of these in conjunction with the USA and the Flight Operations Team.

5.2.11 Deliverables

The UK is required to deliver the following to the USA HIRDLS Program Office:

1. Subsystem specifications (MIL-STD-490A format or equivalent) for the UK subsystems;

2. Schedule estimates for the detailed design, fabrication, and test of an EM and PFM with spares as required for each of the UK subsystems; and

3. Instrument calibration plan with schedule estimates for performing instrument calibration;

4. Thermal and structural math models of UK subsystems or structural, mass-distribution, and thermal properties data as necessary to support structural and thermal modeling of the instrument;

5. UK designed and developed EM and PFM subsystems for system integration; and

6. UK standard data products software for integration into the EOSDIS.

5.3 Joint USA and UK Obligations

5.3.1 Hardware Development

The USA and UK will provide the resources necessary to complete the following as a joint effort:

1. Spacecraft payload integration, test and launch support;

2. Shipping charges for subsystem, components, instruments and support EGSE and MGSE. Shipments from the USA to the UK shall be paid by the USA, and shipments from the UK to the USA shall be paid by the UK; and

3. Assist the spacecraft contractor in the preparation and maintenance of interface control drawings and documentation, configuration and installation drawings, test plans and procedures, test and operational software, and data processing requirements.

5.3.2 Schedules

A HIRDLS program schedule will be developed. Each party will work to this schedule to ensure delivery of the instrument to the spacecraft contractor in order to meet the established instrument delivery and spacecraft launch date.

5.3.3 Interfaces

The interfaces between the HIRDLS Instrument and the EOS Chemistry Spacecraft will be controlled by the HIRDLS Unique Instrument Interface Document (UIID), the GIRD, and the HIRDLS Interface Control Document (ICD) to be developed jointly by the HIRDLS program and the EOS Common Spacecraft manufacturer. The interfaces within the instrument will be controlled by the HIRDLS Internal Interface Control Document. All interfaces which are internal to a single organization will be tracked and controlled by that party.

5.3.4 IST and SCF

The USA and UK shall coordinate the design and specification of their Instrument Support Terminals (ISTs) and each shall provide an IST workstation and software and maintain the IST for instrument test, mission operations and interfacing with the EOC. The GSFC will provide the software necessary to transfer data and commands between the ISTs and the EOC. The IST is required to monitor on-orbit instrument performance and support instrument operations including the diagnosis and resolution of performance anomalies. The UK shall deliver a set of IST software to the USA.

The USA and UK shall each provide a SCF in order to interface with the Distributed Active Archive Center designated to process the HIRDLS data as well as with each other.

5.3.5 Instrument EM

The USA and UK shall develop an Instrument EM with an end item configuration that is form, fit, function, and material equivalent to the instrument PFM. The schedule for the development of the EM shall be such that the results of EM fabrication and testing can be utilized to determine the validity of the detailed design, fabrication procedures, and performance verification planning of the PFM. The EM shall be fabricated under engineering control utilizing good manufacturing practices. It is not a requirement that flight quality parts be used on the EM. The contractor shall characterize the performance of the EM per the instrument science and engineering requirements. EM tasks, including testing, shall be completed by the Critical Design Review (CDR).

5.3.6 Science Research, Data, Algorithm Theoretical Basis Document, and Validation

The USA and UK Co-PIs shall coordinate the science team's activities in carrying out scientific investigations leading to the publication of results in proceedings of scientific meetings and refereed scientific journals. They shall ensure that a citation identifying the NASA EOS Program is contained in each publication resulting from work supported by this joint effort. Copies of each publication shall be provided to RAL and CSFP.

The Co-PIs shall prepare and deliver documents which discuss in detail the scientific objectives of the experiment, the science data required for collection, the instrument design which will be used to collect the data, and the method for processing the data. They shall also identify companion data from other instruments or sources and in situ data, spacecraft data, and calibration data needed for Standard Data Product processing, scientific validation of the algorithms, and flight operations

The Co-PIs shall prepare a document describing the theoretical basis for the algorithms used to generate each standard data product. This Algorithm Theoretical Basis Document (ATBD) will undergo a peer review led by the EOS Project Science Office.

The CO-PIs shall be responsible for the validation of scientific data generated from the HIRDLS instrument in conjunction with the overall EOS data validation activities, and in accordance with the team's scientific investigation objectives and EOS Level 1 requirements. This includes preparation of a Scientific Data Validation Plan for post-launch geophysical validation of HIRDLS data.

5.3.7 Instrument Team Meetings and Reviews

The USA and UK shall jointly be responsible for the preparation of material for participation in the HIRDLS Program reviews and meetings. The Co-PI's will attend meetings as necessary, including meetings of the Investigators Working Group (IWG). The Calibration/Validation Scientists shall attend meetings of the EOS Calibration and Validation Advisory Group as necessary. The USA and UK Co-PI's will meet regularly. Both the Program Team (PT) and Coordination Team (CT) will meet regularly. Other programmatic and/or technical reviews will also be held as necessary. EOS CSFP reviews shall include, but not be limited to:

1. Preliminary Design Review (PDR): This review occurs early in the design phase, approximately 15 months after the Systems Concept Review (SCR). Where applicable, it should include the results of test bedding and breadboard testing. This review shall cover the initial Phase C/D design activity, by which time all fundamental hardware and software design issues shall have been resolved. A Software Requirements Preliminary Design Review (SWPDR) may be part of the PDR or held separately and shall cover the initial software design activity, by which time all fundamental software design issues shall have been resolved. These reviews shall be held at GSFC;

2. Critical Design Review (CDR): This review usually occurs within 18 months after PDR when the design has been frozen but prior to the start of manufacturing flight components. It will emphasize implementation of design approaches as well as test plans for flight systems including the results of engineering model testing. This review shall cover the final design of the instrument. It shall also review breadboard and engineering test results. A Software Critical Design Review (SWCDR) may be part of the CDR or held separately and shall cover the software design as it exists in the early stages of hardware design activity. It shall identify areas of the software design which may be effected by on-going hardware studies. These reviews shall be held at GSFC;

3. Pre-Environmental/Radiometric Calibration Test Review (PER): This review occurs at least 2 weeks prior to the start of environmental testing of the PFM. The primary purpose of this review is to establish the readiness of the system for test and evaluate the environmental test plans. Prior to subjecting a PFM to environmental testing (including thermal vacuum testing) a formal review shall be

conducted to determine readiness for the testing. This determination of readiness for testing shall also apply to all radiometric calibration testing performed under vacuum. Test plans and procedures shall be available for review a minimum of 2 weeks prior to testing. The PER shall be held at the facility at which the testing is to be performed. A delta PER may be required prior to calibration testing in the UK;

4. Pre-Shipment Review (PSR): This review will take place prior to shipment of the flight equipment to the spacecraft contractor, and will concentrate on system performance during acceptance testing and calibration. A review of the history and status of the ProtoFlight Model shall be held before the instrument is shipped to the spacecraft contractor. Additionally, the results of the environmental and radiometric calibration testing, including the thermal vacuum tests of a PFM, shall be formally reviewed. The PSR shall concentrate on instrument system performance testing performed during acceptance testing. The Software Acceptance Review (SAR) shall cover the final software design and shall be presented along with the PSR . The SAR shall include a complete summary of the changes made since the Software Critical Design Review. The SAR shall summarize the software verification procedures and results. The PSR shall be held at GSFC;

5. Quarterly Reviews: Quarterly review meetings for HIRDLS Instrument, Science, and SCF Activities shall be held each year. The locations of these meetings shall be agreed to between the USA and UK. These meetings will be coordinated with instrument development meetings as much as practicable;

6. IWG Meetings: PIs attend whenever required;

7. EOS Payload Panel: PIs participate in the EOS Payload Panel;

8. GSFC DAAC User Working Group: Participate as required;

9. EOSDIS Acceptance Review: Participate in the EOSDIS Acceptance Review conducted by the ESDIS Project. This review will determine the acceptability of the data production software for integration into the DAAC environment;

10. EOSDIS Operations Readiness Review: Participate in the EOSDIS Operations Readiness Review (ORR) conducted by the ESDIS Project;

11. Technical Exchange and Focus Team Meetings: Participate in EOSDIS development by supporting technical exchange meetings and focus team activities as needed, and by reviewing design documents or attending design reviews where instrument participation is required; and

12. Algorithm Peer Reviews: Participate in the algorithm peer reviews conducted by the EOS Project Science Office.

5.3.8 Reports

The USA and UK shall provide to each other, monthly progress reports on all work, both current and planned. It shall be the responsibility of the HIRDLS Program Manager to submit a unified monthly progress report to NASA, RAL, and the Co-PIs. As a minimum the content shall contain:

1. Discussion of effort completed during the current period;
2. Identification of problem areas and proposed corrective action;
3. Evaluation of accomplishments versus planned milestones;
4. Planned activities for the next month; and
5. Common metrics.

The HIRDLS Program Office will submit to the EOS CSFP a monthly technical status report for HIRDLS Instrument Activities. These monthly technical status reports shall be of structure and content format agreed to between the HIRDLS Program Office and CSFP.

5.3.9 Other

The following hardware shall also be manufactured, acquired, or made available to support the program:

1. Specific critical instrument subsystem/components spares;
2. GSE that is necessary and in addition to that which is deliverable; and
3. Computers to support development of ground processing software, in-flight operations, monitoring, post-launch data processing, and scientific application of the data.

6.0 Applicable Documents

The following documents apply in their entirety to all HIRDLS delivered flight hardware and software as well as the SCF and science software. The first five are listed in order of precedence.

The subsequent documents are not listed in order of precedence, and are subordinate to the first five documents:

Pending Release	HIRDLS Letter of Agreement;
424-28-21-06	Unique Instrument Interface Document (UIID) for the High Resolution Dynamics Limb Sounder;
422-11-12-01	General Interface Requirements Document (GIRD) for the EOS Common Spacecraft and Instruments;
424-11-13-01	Mission Assurance Requirements for the High Resolution Dynamics Limb Sounder (HIRDLS) Instrument;
424-28-21-04	Specification for the High Resolution Dynamics Limb Sounder (HIRDLS);
Pending Release	EOS Project Mission Operations Concept;
420-03-01	EOS Project Calibration Management Plan;
423-42-18	Interface Requirements Document between EOSDIS Core System (ECS) and the Science Computing Facility (SCF);
423-16-01	Data Production Software and SCF Standards and Guidelines;
423-16-02	ECS Product Generation System (PGS) Toolkit Requirements Specification;
505-16-03	ECS PGS Toolkit User's Guide, dated (pending release);
420-02-02	EOS Project Configuration Management Plan ;
424-28-11-01	EOS C&SF Instrument Software Management Requirements Document;
424-28-12-01	Instrument Description Document (IDD) for the High Resolution Dynamics Limb Sounder (HIRDLS) EOS Chemistry and Special Flights Project Draft;
505-41-26	Interface Requirements Document for the ESDIS Core System (ECS) and Chemistry, dated (pending release);
424-28-21-03	Documents Requirements Lists for the HIRDLS EOS C&SF Project;

422-36-02 Performance and Operations Specification for the HIRDLS EOS C&SF Project;

209-CD-005-001 Interface Control Document between ECS and the SCF;

209-CD-002-001 Science User's Guide and Operations Procedure Handbook, Part 4; Software Developer's Guide to Preparation, Delivery, Integration, and Test with the ECS; and

DOD-D-100 Military Specification, Drawings, Engineering and Associated Lists. Pending Release Instrument Support Toolkit Prototype Users Guide for the ECS Project, Hughes Applied Information Systems, Inc., Landover, MD, April 1995.